

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner  
 US Department of Commerce  
 United States Patent and Trademark  
 Office, PCT  
 2011 South Clark Place Room  
 CP2/5C24  
 Arlington, VA 22202  
 ETATS-UNIS D'AMERIQUE  
 in its capacity as elected Office

Date of mailing (day/month/year) 21 March 2001 (21.03.01)	
International application No. PCT/GB00/02117	Applicant's or agent's file reference PBA/D088414PWO
International filing date (day/month/year) 12 June 2000 (12.06.00)	Priority date (day/month/year) 10 June 1999 (10.06.99)
Applicant BRENCHLEY, Paul, Ernest, Charles	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

11 December 2000 (11.12.00)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Juan Cruz Telephone No.: (41-22) 338.83.38
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## PATENT COOPERATION TREATY

PCT



REC'D 30 AUG 2001

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## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PBA/D088414PWO	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/02117	International filing date (day/month/year) 12/06/2000	Priority date (day/month/year) 10/06/1999
International Patent Classification (IPC) or national classification and IPC C12Q1/00		
Applicant CENTRAL MANCHESTER HEALTHCARE NHS TRUST et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 3 sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"><li>I <input checked="" type="checkbox"/> Basis of the report</li><li>II <input type="checkbox"/> Priority</li><li>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li><li>IV <input type="checkbox"/> Lack of unity of invention</li><li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li><li>VI <input type="checkbox"/> Certain documents cited</li><li>VII <input checked="" type="checkbox"/> Certain defects in the international application</li><li>VIII <input type="checkbox"/> Certain observations on the international application</li></ul>		
Date of submission of the demand  11/12/2000	Date of completion of this report  27.08.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer  Favre, N  Telephone No. +49 89 2399 7363 	

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/02117

## I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):  
**Description, pages:**

1-16 as originally filed

### Claims, No.:

1-21 as received on 03/07/2001 with letter of 21/06/2001

### Drawings, sheets:

1/1 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02117

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1-21
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-21
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-21
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**Re Item V**

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. The document "WO-A-00 03036" indicated in the search report as a P-document is not to be regarded as state of the art according to Article 33(2) PCT, as the date of priority claimed can be allowed for the relevant parts of the present application, cf. Article 8 PCT.
2. Document D1 (US-A-5 332 812), which is considered to represent the most relevant state of the art, discloses (cf. column 8, lines 15-30, line 57 - column 9, line 39 and column 10, lines 23-28) a method for assaying a sample to determine the heparanase activity thereof from which the subject-matter of independent claim 1 differs in that the polymer substrate further has a paracrine cell regulator bonded to it, whereas D1 does not specifically refer to a paracrine cell regulator and only contemplates the use of a second tag where the substrate is a liquid phase substrate (column 8, line 42 - column 9, line 39).  
Paracrine cell regulators are known in the art to bind to heparanase substrates with an appreciable affinity, see D2 (WO-A-94 20512; page 11, lines 21-34 and page 58, line 28 - page 59, line 17). However, neither D1 nor D2 suggests the use of a paracrine cell regulator bonded to the polymer substrate of D1.  
As emphasised by the applicant (see also page 7, 3rd complete paragraph), said use of a paracrine cell regulator bonded to the polymer substrate of D1 allows the *in vitro* assay to mimic in many respect *in vivo* conditions.
  - 2.1 The problem to be solved by the present invention may therefore be regarded as the modification of the assay of D1 in order to provide an *in vitro* assay that closely mimics the *in vivo* activity of an heparanase on a substrate.
  - 2.2 None of the prior documents at hand discloses such an assay, or fairly suggests to combine and adapt the teachings of D1 and D2 in order to obtain such an assay.  
Hence, the subject-matter of independent claim 1, and of dependent claims 2-15 which further define specific embodiments of the method of D1, is novel and

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/GB00/02117

inventive in the sense of Articles 33(2) and 33(3) PCT.

2.3 Furthermore, the above argumentation also applies to the solid phase support defined in claims 16-19 and to the combination and kit defined in claims 20 and 21, which claims refer to a paracrine cell regulator bonded to the polymer substrate of heparanase.

None of the prior documents at hand discloses or fairly suggests said supports, combination and kit. Claims 16-21 thus meet the requirements of Articles 33(2) and 33(3) PCT.

**Re Item VII**

**Certain defects in the international application**

1. No document reflecting the prior art described is identified in the description (Rule 5.1(a)(ii) PCT).

# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>PBA/D088414PWO</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 02117</b>	International filing date (day/month/year) <b>12/06/2000</b>	(Earliest) Priority Date (day/month/year) <b>10/06/1999</b>
Applicant <b>CENTRAL MANCHESTER HEALTHCARE NHS TRUST</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

#### 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1  
☐ None of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No

PC 00/02117

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 G01N33/52 C12Q1/34

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 G01N C12N C12Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, BIOSIS, MEDLINE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y ✓	US 5 332 812 A (IRIMURA TATSURO ET AL) 26 July 1994 (1994-07-26) page 10, column 8, line 15 - line 33 page 10, column 8, line 57 -page 11, column 9, line 39 page 11, column 9, line 15 - line 22 page 12, column 11, line 22 - line 62 page 15, column 17, line 18 - line 23 ---	1,2,6-21
Y ✓	WO 94 20512 A (GLYCAN PHARM INC) 15 September 1994 (1994-09-15) page 58, line 32 -page 59, line 3 page 8, line 14 -page 9, line 3 page 11, line 21 - line 34 --- -/--	1,2,6-21

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\* & \* document member of the same patent family

Date of the actual completion of the international search

9 January 2001

Date of mailing of the international search report

17/01/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Tuynman, A



# INTERNATIONAL SEARCH REPORT

International Application No

PCT 00/02117

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A ✓	US 5 795 860 A (HERLIHY JR WALTER C ET AL) 18 August 1998 (1998-08-18) page 36, column 37 -page 37, column 39; claims 1-4,8-11,13 ----	1,11-14, 16-18
A ✓	US 5 185 434 A (GROS PIERRE ET AL) 9 February 1993 (1993-02-09) page 16, column 23, line 41 - line 50 ----	1,3,4
P,A ✓	WO 00 03036 A (AYAL HERSHKOVITZ MATY ;HADASIT MED RES SERVICE (IL); PECKER IRIS ( ) 20 January 2000 (2000-01-20) page 11, line 16 - line 37 page 31, line 3 - line 25 page 35, line 36 -page 36, line 4 -----	1-3,5, 15,16

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT 00/02117

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5332812 A	26-07-1994	US 4859581 A AU 609386 B AU 6987087 A DK 122087 A EP 0244932 A FI 871039 A FI 924243 A FI 924244 A NO 870977 A NO 930635 A JP 62265998 A US 5262403 A	22-08-1989 02-05-1991 17-09-1987 04-12-1987 11-11-1987 11-09-1987 22-09-1992 22-09-1992 11-09-1987 11-09-1987 18-11-1987 16-11-1993
WO 9420512 A	15-09-1994	AT 179712 T AU 6353294 A CA 2157388 A,C DE 69418322 D EP 0688327 A EP 0900804 A US 5795860 A	15-05-1999 26-09-1994 15-09-1994 10-06-1999 27-12-1995 10-03-1999 18-08-1998
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WO 0003036 A	20-01-2000	AU 4869799 A	01-02-2000

12/15

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9913415.7 10 June 1999 (10.06.1999) GB

(71) Applicant (*for all designated States except US*): CENTRAL MANCHESTER HEALTHCARE NHS TRUST [GB/GB]; Cobbett House, Manchester Royal Infirmary, Oxford Road, Manchester M13 9WL (GB).

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): BRENCHELEY, Paul, Ernest, Charles [GB/GB]; 5 Dunchurch, Sale, Cheshire M33 5ED (GB).

(74) Agent: ATKINSON, Peter, Birch; Marks & Clerk, Sussex House, 83-85 Mosley Street, Manchester M2 3LG (GB).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— Without international search report and to be republished upon receipt of that report.

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: HEPARANASE ASSAY

(57) Abstract: A method of assaying a sample to determine heparanase activity thereof comprises the steps of (i) incubating the sample in the presence of a first solid phase support having immobilised thereon an HSGAG polymer substrate for the heparanase, the said substrate being insensitive to the action of proteases and the said substrate having bonded thereto a first binding moiety and having further bonded thereto a paracrine cell regulator capable of binding to HSGAG, (ii) treating the incubated sample with a second solid phase support having a second moiety provided thereon capable of immobilising HSGAG polymer substrate cleaved from the first solid phase support on said second solid phase support by binding of said second moiety either with the paracrine cell regulator or with the first binding moiety, (iii) generating a measurable signal the other of the first or second moiety of the cleaved substrate immobilised in the second support solid phase, and (iv) measuring the signal on the second solid phase support separated from the first solid phase support.

WO 00/77241 A2

### HEPARANASE ASSAY

The present invention relates to an assay for heparanase activity

Endoglycosidases are capable of cleaving polymers comprised of glycosaminoglycan units (so called "GAG polymers"). Enzymes that cleave a GAG polymer internally are known as endoglycosidases and include heparanase which cleaves heparan sulphate GAG, hyaluronidase which cleaves hyaluronic acid GAG and chondroitinase which cleaves chondroitin sulphate GAG.

Heparanase has been described in T&B lymphocytes, monocytes, neutrophils, platelets, endothelial cells and in liver and placental tissue. This endoglycosidase activity which degrades heparan sulphate GAG has been variously called heparanase, heparinase, heparitinase and heparan sulphate lyase and almost certainly represents a family of enzymes with different specificities for the internal cleavage site in the GAG polymer.

Heparan sulphate glycosaminoglycans (HSGAGS) of which heparin, the anticoagulant is an example, are highly N- and O-sulphated carbohydrate polymers of glucuronic (sometimes iduronic) acid and glucosamine (sometimes N-acetylated). The high anionic charge is not randomly distributed throughout the polymer but is thought to form clusters of charged residues imparting specific functional binding properties to the sequence. This is demonstrated by the most important anti-coagulant properties of the pentasaccharide sequence in heparin and its interaction with anti-thrombin III..

HSGAG is present in the extracellular matrix, in basement membranes and on cell surfaces. HSGAG is known to play an important role in linking the component structural proteins of the basement membrane, controlling the permeability properties of the membrane (best illustrated in the glomerular basement membrane) and controlling the bio-availability of cytokines and growth factors.

Heparanases are known to play important roles in areas of discovery biology

- a) cancer metastasis; the most metastatic cells display the highest levels of heparanase enzyme which may enable cancer cells to degrade HSGAG in ECM and basement membranes to facilitate tissue invasion. Cancer cells secreting heparanase may support angiogenesis, tumour vascularisation and therefore tumour growth. This is a prime area for developing novel antagonists to heparanase as part of a therapeutic strategy to suppress and inhibit metastasis.
- b) in inflammatory joint disease e.g. rheumatoid arthritis; angiogenesis in the joint may support the chronic inflammatory pathology. Agents inhibiting heparanase in the joint may reduce angiogenesis and therefore suppress the formation of the inflammatory pannus of tissue which causes degradation of cartilage and erosion of bone.
- c) in proteinuric disease; HSGAG expression within the glomerular basement membrane controls the passage of anionic charged proteins e.g. albumin. In early diabetic nephropathy there is evidence of reduced basement membrane HSGAG associated with microalbuminuria. Furthermore, a number of clinical and experimental studies document reduction in proteinuria associated with low molecular weight heparin treatment. These findings support the role of increased heparanase expression within the glomerulus which might be treated with suitable antagonists.

Known assays (summarised below) for heparanase activity have a number of disadvantages.

- (i) Radiolabelled substrate.

In vitro metabolic radiolabelling of cell cultures with  $^{35}\text{SO}_4$  or  $^3\text{H}$  incorporated into HSGAG is commonly used for detecting heparanase. The radiolabelled GAG

may be used following isolation and purification by coupling to a solid phase support. Alternatively, radiolabelled ECM laid down on culture dishes with the cell layer removed, may be used as substrate. Alternatively,  $^3\text{H}$  or  $^{125}\text{I}$  labelling of purified HSGAG or heparin is performed and the labelled substrate coupled to a solid phase. Heparanase activity is detected by loss of radiolabel and or reduction in molecular size of labelled species.

The radiolabelling procedures are hazardous and require special disposal procedures. Large variations in specific activity of substrate occur between batches. The batches of  $^{35}\text{SO}_4$  substrate have a short lifetime of 2 to 3 months.

(ii) HS Substrate showing sensitivity to other enzymes

Assays claiming to measure heparanase that use heparan sulphate proteoglycan as the substrate and detect apparent enzyme activity by identifying release of labelled HSGAG or a reduction in the size profile of HSGAG (using isotope or other label) by molecular sieving are not specific for heparanase. A wide range of proteases present in the sample could act on the proteoglycan component to solubilise significant quantities of HS chains and cause reduction in size by further removal of attached protein. Other enzymes e.g. hyaluronidase may cleave the substrate. Few current assays have demonstrated insensitivity to this range of enzymes.

(iii) Sensitivity and quantitation

Assays requiring long incubation times (4-24 hours) to achieve an effect indicate a lack of sensitivity and leave open the possibility of interference by non-specific factors (e.g. proteases).

Assays requiring molecular sieving to identify the outcome of heparanase activity are only qualitative in nature

(iv) Multiple sample handling

Assays requiring centrifugation or molecular sieving to separate the products of heparanase activity only allow small batch assays to be performed.

It is an object of the present invention to obviate or mitigate the above mentioned disadvantages.

According to a first aspect of the present invention there is provided a method of assaying a sample to determine heparanase activity thereof the method comprising

- (i) incubating the sample in the presence of a first solid phase support having immobilised thereon an HSGAG polymer substrate for the heparanase, the said substrate being insensitive to the action of proteases and the said substrate having bonded thereto a first binding moiety and having further bonded thereto a paracrine cell regulator capable of binding to HSGAG,
- (ii) treating the incubated sample with a second solid phase support having a second moiety provided thereon capable of immobilising HSGAG polymer substrate cleaved from the first solid phase support on said second solid phase support by binding of said second moiety either with the paracrine cell regulator or with the first binding moiety,
- (iii) generating a measurable signal the other of the first or second moiety of the cleaved substrate immobilised in the second support solid phase, and
- (iv) measuring the signal on the second solid phase support separated from the first solid phase support.

In a second aspect, the invention provides, for the use in an assay as defined above, a solid phase support (equivalent to the aforementioned first support) having immobilised thereon an HSGAG polymer substrate for heparanase, said substrate having bonded thereto a first binding moiety and having further bonded thereto a paracrine cell regulator capable of binding to HSGAG, said first moiety or said paracrine cell regulator being capable of binding to a second moiety.

In a third aspect, the invention provides the combination of first solid phase support as defined in the previous paragraph and second solid phase support having provided thereon a second moiety capable of binding to either the first moiety or the paracrine cell regulator to form a complex therewith.

In a fourth aspect, the invention provides an assay kit comprising the combination of the previous paragraph and signal developing agents to generate a signal representative of the result of the assay.

The paracrine cell regulator may, for example, be a growth factor, cytokine or chemokine.

The assay of the invention allows rapid quantitation of heparanase activity in a sample having, or potentially containing, such activity.

The invention is further described with reference to the paracrine cell regulator being an HSGAG binding growth factor but it is to be understood that the invention is equally applicable to other paracrine cell regulators.

The assay is conducted using a solid phase format. Step (i) of the assay uses a first solid phase support on which is immobilised an HSGAG polymer substrate which is cleavable by the heparanase present (or potentially present) in the sample. Bonded to this polymer substrate are

- (a) HSGAG binding growth factor, and



(b) a first binding moiety

The HSGAG substrate bonded to the support is insensitive to the action of proteases at concentrations normally found in clinical samples (otherwise the assay would give a false positive result). This may be achieved by ensuring that the HSGAG substrate is bonded to the first solid phase support otherwise than via any residual small peptide chain in the substrate derived from the proteoglycan from which the HSGAG substrate has been purified. For this purpose, the procedure of immobilising the HSGAG substrate on the support may involve oxidation of the sugar residue of the substrate (e.g. using periodate as described in the experimental protocol described *infra*).

Given that there is heparanase activity in the sample, the procedure of step (i) results in cleavage of HSGAG polymer substrate in an amount which is dependent on the degree of herparanase activity in the sample and its ability to cleave the HSGAG polymer substrate in the presence of the growth factor bonded thereto.

Any cleaved HSGAG polymer substrate (having both the first moiety and the growth factor bonded thereto) is released into the analyte phase. Confirmation that HSGAG-growth factor has been removed from the solid phase in step (i) can be obtained after step (ii) by incubating the washed heparanase treated solid phase with (strept)avidin-conjugated enzyme or anti-growth factor conjugated enzyme and comparing the signal with that obtained from a control solid phase. Heparanase activity significantly reduces the signal obtained.

In step (ii), the analyte phase is treated with a second solid phase support system incorporating a second moiety capable either of forming a complex with the first binding moiety or capable of forming a complex with the growth factor. As a result, complex formation between the first and second moieties occurs or complex formation between the growth factor and the second moiety occurs resulting in the cleaved fragments becoming immobilised on the second solid phase support. Either

the first moiety or the growth factor remains unbound and is used for signal development.

In step (iii), a measurable signal is generated from the cleaved fragments immobilised on the second solid phase support. The signal may be dependent on the growth factor component of the complex ( where the complex is captured by the first binding moiety and detected with anti-growth factor antibody) and enzyme coupled anti-species antibody. Alternatively, where the complex is captured by anti-growth factor antibody the signal may be generated by an enzyme coupled to a third moiety capable of binding to the first moiety. The signal may for example, be a colorimetric signal and be measured by a spectrophotometer. Alternatively the signal may be a fluorescent signal which facilitates automation of the assay with high throughput.

Finally in step (iv), the signal generated in step (iii) is measured. This measurement is effected with the second solid phase support system separated from the first such system (i.e. that employed in step (i)) so that the signal is measured otherwise than in the environment of said first such system.

The measured signal is representative of the specific heparanase activity in the original sample. More particularly, the measured signal directly reflects the biological action in generating complexes of growth factor-HSGAG that would be produced in physiological and pathological states.

A critical control point in these pathologies is the bioavailability of important cytokine, chemokine and growth factors. On release from the secreting cell, most of the mediator(>70%) would normally interact with HSGAG in extracellular matrix (ECM) to form a stable reservoir of mediator. Only a fraction of the secreted mediator directly and immediately binds to the specific mediator receptor on the target cell to initiate cell signalling. Heparanase enzymes provide critical control of this reservoir

by releasing these biologically specific growth factors from ECM that can bind their target receptors and initiate signalling.

Cytokines that bind HSGAG include IL-1 $\alpha$  and IL-1 $\beta$ , IL-2, IL-4, IL-7, IL-8, IL-12, TNF $\alpha$ , IFN $\alpha$ . Chemokines that bind HSGAG include IP-10, MCP-1. Growth factors that bind HSGAG include VEGF, FGF-1, FGF-2, TGF $\beta$ 1, PDGF, HGF. The term growth factor will be used to denote any of these mediators. The invention will measure heparanase activity using any of these heparan sulphate binding GFs

The heparanase-released growth factor in the form of a complex of variable length of HSGAG sequence bound to growth factor may be significantly more active biologically than the native growth factor.

The binding sites in HSGAG that interact with these growth factors are poorly described at present and it may be that each growth factor has a unique binding site. Alternatively, some growth factors may share a certain binding sequence in HSGAG.

Heparanases from different cell sources may be differentiated from each other by their ability to solubilise particular growth factors or combinations of growth factors from HSGAG. This will happen where the binding of growth factor to the HSGAG substrate protects or sterically occludes a potential enzyme cleavage site. Thus by use of a panel of growth factors bound to HSGAG, it may be possible to attribute a particular pattern of GF solubilisation to a heparanase from platelets compared to synovial fluid or tumour. This may be of importance for instance in differentiating the action of a tumour heparanase from platelet derived heparanase.

Of considerable importance in the design of antagonists of heparanase function is the use of this method to generate selective heparanase inhibitors of exquisite specificity such that inhibition is confined to those HSGAG cleavage sites linked with solubilisation of a certain growth factor. Thus, for instance, a specific inhibitor of VEGF solubilisation may reduce and suppress tumour angiogenesis and

metastasis without inhibiting the immune functions of a platelet heparanase in solubilising IFN $\alpha$  to protect from infection during wound healing.

The assay is unaffected by the presence of proteases, hyaluronidase and chondroitinases. The assay is sensitive only requiring incubation times at step (i) of 30-60 minutes.

The method of the invention may be used for determining heparanase activity in a biological sample, e.g. for the purposes of diagnosing or characterising a particular medical condition. It is however envisaged that an important application of the invention will be in the screening of potential inhibitors or enhancers of heparanase activity. Thus, for example, the assay may be conducted with an analyte containing an heparanase and a putative inhibitor therefore to determine the effect (or otherwise) of that inhibitor.

Preferred embodiments of the Invention will now be described.

The assay of the invention is particularly useful for determining heparanase activity, e.g. for the purpose of evaluating potential inhibitors thereof.

The GAG polymer substrate immobilised on the support is preferably heparan sulphate glycosaminoglycan.

The first solid phase support system (i.e. the system in which the HSGAG polymer substrate is immobilised) is preferably a microtitre well. The assay may be conducted using a tray of microtitre wells or larger arrays having immobilised HSGAG polymer substrate. As such, the assay of the invention may be effected using robotic technology to screen compounds for anti-heparanase activity. When using a microtitre well as the first support system, the second solid phase support system may be a microtitre plate lid with a coated probe extending into each assay well as the second support system, for example, NUNC® TSP screening system or FALCON® FAST system. In this case, step (i) and step (ii) of the assay take place during the

same incubation time. Alternatively, the second solid phase may be another coated microtitre well and step (i) and step (ii) occur sequentially and require physical transfer of the contents of the first well to the second well.

If the cleaved substrate is to be captured (on the second solid phase support) by the first moiety then the first moiety may be biotin and the second moiety strept(avidin). In this case the signal may be generated by means of an anti-growth factor antibody and enzyme coupled anti-species antibody.

If the cleaved substrate is to be captured by the growth factor then the second moiety may be anti-growth factor antibody. In this case the first moiety may be biotin and the signal generated by an enzyme coupled to (strept)advin (as the aforementioned third moiety).

The method of the invention may be effected using the following protocol.

The GAG polymer substrate may be tagged with biotin using simple photobiotylation chemistry. A mixture of photobiotin (1mg/ml) and HSGAG (10mg/ml) in phosphate buffered saline (PBS) at a ratio of 2:1 (vol/vol) is exposed to UV light emitted from a Mercury arc HBO50 W lamp used as a microscope UV source for 21 minutes at a distance of 10 cm. The biotinylated HSGAG is dialysed against PBS for 18 hours at 4°C and stored at -20°C.

The immobilisation of the GAG polymer substrate on the solid phase support is carried out after the tagging with the first complex forming moiety and may be effected by oxidising the substrate with periodate and incubation with carbohydrate binding multiwell plates (for example, COSTAR® or NUNC plates may be used) to yield a surface to which the substrate is covalently and stably bonded. Specifically, sodium periodate at 10µM and biotinylated HSGAG at 5µg/ml in sodium acetate buffer (10mM, pH 4.0) are allowed to interact for upto 15 minutes and then 100µl of the activated biotinylated HSGAG is added to each well of the carbohydrate binding assay plate for 1 hour, shaking at 37°C. The plates are then washed thoroughly in

PBS containing 0.1% Tween® 20. 100µl of 1% bovine serum albumin (BSA) in PBS is added to each well and incubated at 37°C for 60 minutes to block any nonspecific binding sites on the plate. Following washing with PBS, the coated plate may be used immediately or stored wrapped in cling film at 4°C for several months.

Once the GAG polymer substrate has been immobilised in the first support, it (i.e. the substrate) may be treated with a GAG binding growth factor (e.g. VEGF, TGF β1, MCP-1, IFN-γ, see list in claim 8). 100µl of GF at 1-5µg/ml in PBS is added to each well and incubated for 18 hours at 4°C. Following washing in PBS, the plate is ready for use.

The second solid phase support may be prepared by coating the support material with the second complex forming moiety (e.g. (strep)avidin blocked with BSA). The microwell lid probes or wells, where the second solid phase is another well, are coated with (strept)avidin at 1-5µg/ml in PBS for 18 hours and following washing in PBS they are blocked with BSA as above.

To carry out the assay, the analyte having (or potentially having) heparanase activity is incubated in the presence of the first solid phase support system. The analyte is diluted in enzyme assay buffer which is sodium acetate (0.1M, pH 5.5 containing  $\text{Ca}^{2+}$  (5mM),  $\text{Cu}^{2+}$  (1mM) and  $\text{Fe}^{3+}$  (1mM). Each assay includes as controls, wells without biotinylated HSGAG coating and wells which do not receive the test sample. The heparanase assay is allowed to proceed for 1 hour normally (but may range from 30minutes to 4 hours) on a plate shaker at 37°C. Where the second solid phase is a well lid coated probe, steps (i) and (ii) occur simultaneously, where the second solid phase is another coated well, the supernatant from the first well is transferred to the second well and incubated for 2 to 24 hours.

As a result, any biotinylated HSGAG-GF substrate cleaved from the first solid phase support during incubation becomes immobilised on the second support which may now be separated from the analyte.

A signal is then developed. Where the second solid phase used strep(avidin) to capture the complex through its biotin moiety, this may be achieved by incubating the second solid phase support with anti-growth factor antibody followed by enzyme-conjugated anti-species IgG. Where the second solid phase used anti-growth factor antibody to capture the complex, signal may be developed by incubating with enzyme-conjugated strep(avidin). Confirmation that the substrate bound to the first solid phase has been cleaved can be obtained by incubation with either enzyme conjugated strep(avidin) or enzyme conjugated antibody. The preferred enzyme conjugated to these detection reagents is peroxidase and therefore the amount of peroxidase activity associated with the well probe may be revealed using a standard TMB substrate colour change and spectrophotometry.

The invention will be illustrated by the following non-limiting Example and Reference Examples and the accompanying drawings which illustrate the results of Reference Examples 1 and 2.

#### Reference Example 1

This Reference Example demonstrates the specificity of biotinylated HSGAG for heparanase.

Biotinylated HSGAG was prepared using the procedure described in the above protocol and immobilised on microtitre wells as the solid phase support, again using the procedure of the protocol

Separate samples of the support-bound biotinylated HSGAG were incubated for 1 hour at 37 °C with a number of enzymes at very high concentrations (> 100 fold than would be encountered in clinical samples) including proteases e.g. dispase, thrombin, collagenase, trypsin, plasmin, pepsin and glycosidase e.g. neuraminidase and endoglucoronidases e.g. heparanase, hyaluronidase and chondroitinase at the initial concentrations shown in the following Table 1.

**TABLE 1**

Enzyme	Initial Concentration
Heparanase	Spleen extract (neat)
Hyaluronidase	25mg/ml
Dispase	1mg/ml
Thrombin	250U/ml
Collagenase	1mg/ml
Trypsin	1mg/ml
Plasmin	1U/ml
Pepsin	1mg/ml
Chondroitinase	5U/ml
Neuraminidase	1mg/ml

After the initial incubation period, the % release of HSGAG was determined by the following procedure. 100µl of avidin peroxidase at 1:1000 dilution in PBS was added to the plate for 60 mins at 37 °C. After washing three times in PBS Tween, 100µl of TMB substrate (100ug/ml) was added and the colour development was assayed in end point mode at 450nm after stopping the reaction with 100ul of 0.1M HCl.

The above procedure was repeated for all the above enzymes using dilution factors of 400 and 800 as compared to its initial concentration.

The results are plotted in Fig 1 of the accompanying drawings.

The plot of Fig 1 clearly demonstrates the specificity of the biotinylated HSGAG for Heparanase.

Only Hyaluronidase, Dispase and Thrombin appeared to have a minor effect on the substrate which in the case of dispase and thrombin disappeared with dilution (Fig 1). Collagenase, Trypsin, Plasmin, Pepsin, Chondroitinase and Neuraminidase



had no discernable effect on the substrate with % release for these enzymes too low to be plotted on the graph..

### Reference Example 2

This Reference Example demonstrates that support-bound biotinylated HSGAG is cleaved from the solid phase by heparanase treatment.

Samples of biotinylated HSGAG immobilised on solid phase were prepared as in the above described protocol.

A dilution series of spleen extract of heparanase was prepared, added to separate samples of the support-bound HSGAG substrate and incubated for 60 minutes. The support was then washed followed by addition of avidin peroxidase 1:1000 for 30-60 minutes at 37 ° C. Peroxidase substrate TMB 100ug/ml was added and colour change measured by spectrophotometry.

The results are plotted in Fig 2 which demonstrates that loss of biotinylated HSGAG was proportional to heparanase dilution over two orders of magnitude.

### Reference Example 3

This Reference Examples demonstrates that a complex of HSGAG and Growth factor can be cleaved from the solid phase.

Biotinylated HSGAG prepared as in the above described protocol was immobilised on a solid support using the procedure of the above described protocol.

Recombinant growth factor/cytokine (63ng/ml in PBS) was incubated in the wells overnight to allow binding to the HSGAG and form a solid phase bound complex. Unbound GF/cytokine was removed by washing three times with PBS.

A standard dilution 1:20 of spleen heparanase enzyme was added to the wells for one hour and the amount of GF/cytokine remaining was detected by use of a specific anti-GF/cytokine antibody. This antibody was detected by an anti-species peroxidase coupled reagent followed by substrate development.

The results were as shown in the following Table 2.

Growth Factor/Cytokine	% reduction in GF after heparanase treatment
VEGF	68.7
IFN $\gamma$	73.7
MCP-1	81.2
TGF $\beta$ 1	79.9

The results demonstrate cleavage of the complex of HSGAG and GF/cytokine from the solid phase by the heparanase.

#### Example 1

This Example demonstrates detection of biotinylated HSGAG-Growth factor complexes.

Biotinylated HSGAG prepared as in the above described protocol was immobilised on a solid support, again using the procedure of the protocol.

Recombinant VEGF (63 ng/ml in PBS) was incubated in the wells overnight to allow binding to the HSGAG and form a solid phase bound complex of the HSGAG and VEGF.

Unbound VEGF was removed by washing three times with PBS.

Heparanase enzyme from spleen at 1:10 dilution was added to the wells for one hour. Subsequently the well contents were transferred to another ELISA plate

precoated with monoclonal anti-VEGF antibody (5µg/ml for 16 hours) and incubated for 4 hours. During incubation, heparanase cleaved soluble complexes containing biotinylated HSGAG bound to VEGF (which complexes are derived from the first plate) were bound to the anti-VEGF coated plate. After washing, the presence of biotinylated HSGAG bound to the anti-VEGF well was detected with avidin peroxidase followed by addition of peroxidase substrate.

The results are shown in the following Table 3 which also includes results for Background and Controlled Experiments as detailed in the Table.

Table 3

Experiment	Procedure	OD 450nm
Invention	(+heparanase + VEGF + anti-VEGF)	0.168
Background	(no heparanase, no VEGF, no anti-VEGF coat)	0.083
Control 1	(no heparanase + VEGF + anti VEGF)	0.097
Control 2	(+heparanase, no VEGF, no anti-VEGF)	0.095

It will be seen from the above results that the procedure of the invention resulted in capture of the cleaved complex of VEGF and biotinylated HSGAG by anti-VEGF antibodies, with detection of the cleaved complex by avidin-peroxidase.

### CLAIMS

1. A method of assaying a sample to determine heparanase activity thereof the method comprising
  - (i) incubating the sample in the presence of a first solid phase support having immobilised thereon an HSGAG polymer substrate for the heparanase, the said substrate being insensitive to the action of proteases and the said substrate having bonded thereto a first binding moiety and having further bonded thereto a paracrine cell regulator capable of binding to HSGAG,
  - (ii) treating the incubated sample with a second solid phase support having a second moiety provided thereon capable of immobilising HSGAG polymer substrate cleaved from the first solid phase support on said second solid phase support by binding of said second moiety either with the paracrine cell regulator or with the first binding moiety,
  - (iii) generating a measurable signal the other of the first or second moiety of the cleaved substrate immobilised in the second support solid phase, and
  - (iv) measuring the signal on the second solid phase support separated from the first solid phase support.
2. A method as claimed in claim 1 wherein the HSGAG polymer substrate is covalently bonded to the first solid phase support system.
3. A method as claimed in claim 1 or 2 wherein the first solid phase support system is a microtitre well.

4. A method as claimed in claim 3 wherein the second solid phase support system is a plate lid probe.
5. A method as claimed in claim 3 wherein the second solid phase support system is a microtitre well.
6. A method as claimed in any of claims 1 to 5 wherein the second solid phase support system is separated from the first solid phase support system between steps (ii) and (iii).
7. A method as claimed in any one of claims 1 to 6 wherein, in step (ii), HSGAG polymer substrate cleaved from the first solid phase support is immobilised in the second solid phase support by binding of the first and second moieties.
8. A method as claimed in claim 7 wherein the first moiety is biotin and the second moiety is strept(avidin).
9. A method as claimed in claim 7 or 8 wherein the signal is generated by an anti- paracrine cell regulator antibody and enzyme coupled anti-species antibody.
10. A method as claimed in claim 9 wherein the signal is developed by incubating the second solid phase support with anti- paracrine cell regulator antibody followed by peroxidase anti-species IgG.
11. A method as claimed in any one of claims 1 to 6 wherein, in step (ii), the HSGAG polymer substrate cleaved from the first solid phase support is immobilised on the second solid phase support by binding of the paracrine cell regulator and the first moiety.
12. A method as claimed in claim 11 wherein the signal is generated by an enzyme coupled to a third moiety capable of binding to the first moiety.

13. A method as claimed in any one of claims 1 to 12 wherein the paracrine cell regulator is a growth factor, a cytokine or a chemokine.

14. A method as claimed in claim 13 wherein the paracrine cell regulator is a growth factor and is selected from VEGF, TGF $\beta$ 1, FGF-1, FGF-2, HGF, PDGF, IL-1 $\alpha$ , IL-1 $\beta$ , IL-2, IL-4, IL-7, IL-8, IL-12, IP-10, MCP-1, TNF $\alpha$  or IFN- $\alpha$ .

15. A method as claimed in any of claims 1 to 14 for determining the activity of a putative inhibitor of heparanase activity.

16. A solid phase support having immobilised thereon an HSGAG polymer substrate having bonded thereto a first binding moiety and a paracrine cell regulator capable of binding to HSGAG, said first moiety or said paracrine cell regulator being capable of binding to a second moiety.

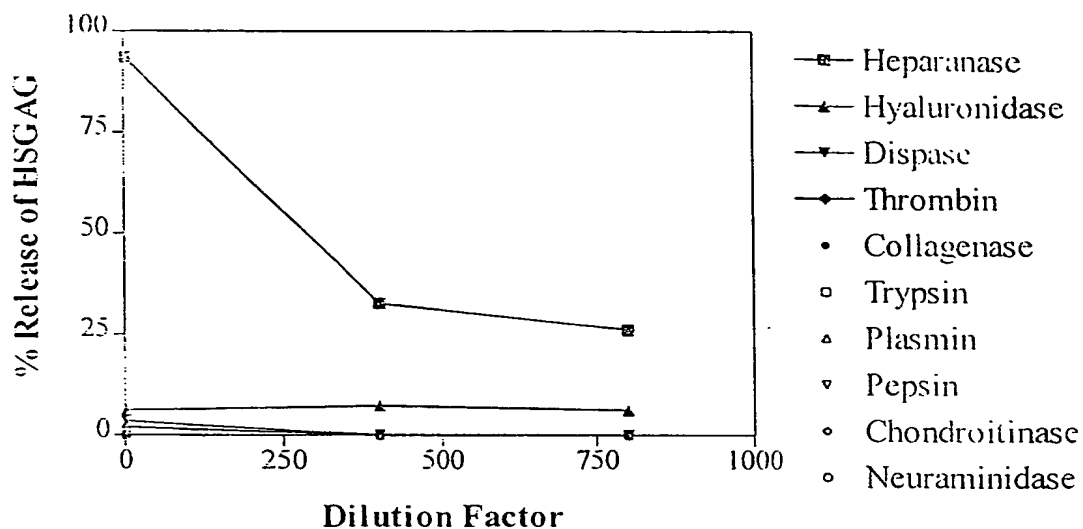
17. A support as claimed in claim 16 wherein the paracrine cell regulator is a growth factor, chemokine or cytokine.

18. A support as claimed in claim 17 wherein the paracrine cell regulator is selected from VEGF, TGF $\beta$ 1, FGF-1, FGF-2, HGF, PDGF, IL-1 $\alpha$ , IL-1 $\beta$ , IL-2, IL-4, IL-7, IL-8, IL-12, IP-10, MCP-1, TNF $\alpha$  or IFN- $\alpha$ .

19. A support as claimed in any one of claims 16 to 18 wherein the first moiety in biotin.

20. The combination of a solid phase support as claimed in any one of claims 16 to 19 and a second solid phase support having provided thereon said second moiety.

21. An assay kit comprising the combination as claimed in claim 20 and signal developing agents to generate a signal representative of the result of the assay.

**FIG 1****FIG 2**

Spleen heparanase activity on  
solid phase substrate

